MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2016/2017

EMG4066 – ANTENNA AND PROPAGATION
(TE)

08 MARCH 2017
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTION TO STUDENT

1. This question paper consists of 5 pages including cover page with 4 questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the provided answer booklet.

Question 1

(a) Consider a short dipole made of a thin conductor of length $\lambda/_{100}$ is located at the origin and fed with a current of $0.25\sin 10^{8} t$ A. Determine the magnetic field at $r = \lambda/_{5}$ and $\theta = 30^{o}$.

[12 marks]

(b) A quarter-wavelength (resonant) monopole is to be used to set-up an electric field at a distance of 500 km away. The monopole operates at a frequency of 50 MHz. The required electric field strength is 10 μV/m, and the observation point is at the boresight ($\theta = \pi/2$) of the dipole. The magnitude of the electric field $|E|$ at a distance r away from the dipole with a current I_o is given by,

$$|E| = \frac{\eta_o I_o \cos\left(\dfrac{\pi}{2}\cos\theta\right)}{2\pi r \sin\theta}$$

where η_o is the free space impedance and θ the angle from the z-axis (given that dipole is parallel to the z-axis). Determine the length of the monople in meter, calculate the current that must be fed to the antenna, and find the average power radiated by the antenna assuming that the monopole has an radiation resistance of 36.56 Ω.

[13 marks]

Question 2

(a) Evaluate the directivity of an antenna with normalized radiation intensity given by

$$U(\theta,\phi) = \begin{cases} \sin\theta & , \quad 0 \le \theta \le \dfrac{\pi}{2}, 0 \le \phi \le 2\pi \\ 0 & , \quad elsewhere \end{cases}$$

[15 marks]

(b) An antenna test range is to be used to measure far field radiation pattern of a newly designed antenna. The frequency range of interest is from 900 MHz to 1.8 GHz. The aperture of the antenna is 20 cm x 40 cm. Determine the required minimum distance for the test range to obtain far field radiation pattern..

[10 marks]

Continued...

Question 3

(a) Derive an array factor expression for the group of a linear array of *N* elements. Assume that the elements are placed along the *z*-axis, oriented parallel to the *x*-axis with spacing *d* and inter element phase shift α.

[15 marks]

(b) An antenna can be modeled as an electric dipole of length 5 m at 3 MHz. Find the radidation resistance of he antenna assuming a uniform current over its length.

[5 marks]

(c) A half-wave dipole fed by a 50 Ω transmission line, calculate the reflection coefficient and the standing wave ratio.

[5 marks]

Question 4

(a) Prove the following Friis transmission equation.

[8 marks]

$$P_r = P_t \bullet G_t \bullet G_r \left(\frac{\lambda}{4\pi d} \right)^2$$

(b) From section (a), determine the free space loss.

[4 marks]

(c) When the maximum electron density of the ionospheric layer corresponds to refractive index of 0.92 at the frequency of 10 MHz, determine the range if the frequency is MUF itself. The height of the ray reflection point on the ionospheric layer is 400 km. Assume flat earth and negligible effect of earth magnetic field.

[13 marks]

End of paper.

APPENDIX

Constants and Formulae (All symbols have their usual meanings)

Constants and Formulae:

Boltzmann's constant	$k = 1.38 \times 10^{-23} J/k$
Plank's constant	$h = 6.6266 \times 10^{-34} J.s$
Light velocity in free space	$c = 3 \times 10^{8} m/s$
Electron Charge	$e = 1.6 \times 10^{-19} C$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7} H/m$
Permittivity of free space	$\varepsilon_o = \frac{10^{-9}}{36\pi} F/m$

$$P_{rad} = 40\pi^2 \left[\frac{L}{\lambda}\right]^2 I_m^2$$

$$AF = a_1 e^{j\alpha_1} + a_2 e^{j(\beta d\cos\theta + \alpha_2)} + a_3 e^{j(2\beta d\cos\theta + \alpha_3)} + \ldots + a_N e^{j((N-1)\beta d\cos\theta + \alpha_N)}$$

$$|AF| = \frac{\sin(N\psi/2)}{\sin(\psi/2)}, \quad \psi = \beta d\cos\theta + \alpha$$

If n is fractional or negative and $|x| \prec 1$

$$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)}{2!}x^2 \pm \frac{n(n-1)(n-2)}{3!}x^3$$

$$P_D = \frac{P_{tx} G_{tx}}{4\pi R_{tx}^2} \qquad h_{inc} = \frac{D_1 D_2}{2KR} \qquad r = \sqrt{\frac{D_1 D_2 \lambda}{D_1 + D_2}}$$

$$E = \frac{\sqrt{30 P_t \bullet G_t}}{d} \qquad E_R = 2\frac{E_0}{d}\sin\left(\frac{2\pi}{\lambda} \bullet \frac{h_t h_r}{d}\right)$$

$$n = \sqrt{\varepsilon_r} = \frac{\sin\theta_i}{\sin\theta_r} = \sqrt{1 - \frac{81N}{f^2}} \qquad MUF = f_{cr} Sec\theta_i$$

SPHERICAL COORDINATES (R, θ, ϕ)

$$\nabla V = \hat{\mathbf{R}}\frac{\partial V}{\partial R} + \hat{\boldsymbol{\theta}}\frac{1}{R}\frac{\partial V}{\partial \theta} + \hat{\boldsymbol{\phi}}\frac{1}{R\sin\theta}\frac{\partial V}{\partial \phi}$$

$$\nabla \cdot \mathbf{A} = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2 A_R) + \frac{1}{R\sin\theta}\frac{\partial}{\partial \theta}(A_\theta \sin\theta) + \frac{1}{R\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

$$\nabla \times \mathbf{A} = \frac{1}{R^2\sin\theta}\begin{vmatrix} \hat{\mathbf{R}} & \hat{\boldsymbol{\theta}}R & \hat{\boldsymbol{\phi}}R\sin\theta \\ \frac{\partial}{\partial R} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \phi} \\ A_R & RA_\theta & (R\sin\theta)A_\phi \end{vmatrix}$$

$$= \hat{\mathbf{R}}\frac{1}{R\sin\theta}\left[\frac{\partial}{\partial\theta}(A_\phi \sin\theta) - \frac{\partial A_\theta}{\partial \phi}\right] + \hat{\boldsymbol{\theta}}\frac{1}{R}\left[\frac{1}{\sin\theta}\frac{\partial A_R}{\partial \phi} - \frac{\partial}{\partial R}(RA_\phi)\right] + \hat{\boldsymbol{\phi}}\frac{1}{R}\left[\frac{\partial}{\partial R}(RA_\theta) - \frac{\partial A_R}{\partial \theta}\right]$$

$$\nabla^2 V = \frac{1}{R^2}\frac{\partial}{\partial R}\left(R^2\frac{\partial V}{\partial R}\right) + \frac{1}{R^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial V}{\partial\theta}\right) + \frac{1}{R^2\sin^2\theta}\frac{\partial^2 V}{\partial\phi^2}$$